# *Healthcare support for underserved communities using a mobile social media platform*



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**Abstract**

Emerging digital technologies for healthcare information support have already contributed to reducing the digital divide among rural communities. Although mobile health (m-health) applications facilitate provision of support for treatment consultation in real-time, their substantial potential has not yet been operationalised for decision support to meet citizen demand in developing nations. Modern healthcare information access, especially in rural areas of developing countries, is critical to effective healthcare, since both information and expert opinions are limited. Mobile phone and social media penetration, however, is often extensive. In this paper, we design and evaluate an innovative mobile decision support system (MDSS) solution for rural citizens healthcare decision support and information dissemination.

Developed using a design science approach, the instantiated artifact connects underserved rural patients in Bangladesh to general practitioners (GPs) – allowing GPs, based on queries and information support provided, to evaluate patient conditions virtually and provide answers for further diagnosis or treatment. A cloud platform using social media embodies health record information and is used with a rating technique that matches queries to profiled remote experts, participating asynchronously. A comprehensive evaluation of the MDSS artifact ensures its utility, efficacy, and reliability.

**Keywords:** underserved citizens, decision support, healthcare information, m-health, design science, social media.

## 1. Introduction

Advanced information and communication technologies are transforming society by addressing the digital divide, the most recognised “social issue” for empowering rural citizens [41]. Rural citizens in developing countries have been suffering from “digital divide” in healthcare support due to limited access to experts and electronic health (e-health) information. As part of e-health, Mobile-health (m-health) provides many benefits such as enhancing self-management [28] and reducing travelling and medical expenditure [10]. Over the past two decades much academic and commercial research has been conducted on improving m-health technologies, mainly focused on identifying specific relevant issues, exploration of potential benefits, and new technology development. Varshney [53] however, noted that m-health in developing countries suffers from a range of barriers such as lack of infrastructure, cultural and social resistance, lack of education, and the role of medicine. Our case example of Bangladesh illustrates a developing country with a good digital infrastructure, but research attention in m-health is generally lacking in the developing countries context. IS research should promote "the productive application of information technology to human organisations and their management" (ISR (2002) cited in Hevner et al. [24, p. 76] and motivates creative solutions for healthcare information support for rural, remote and other underserved communities. Using design science, we therefore aim to develop and evaluate an innovative solution artifact for Bangladesh's rural communities to reduce the digital divide in m-health provision.

Various innovative m-health applications have been introduced in recent years. As well as extending healthcare coverage [29], other design directions include supervising support services [27], improving hospital management [11], motivating support service [51], improving training support [37], providing suitable healthcare in emergencies [19], and improving decision making [7]. Alongside these providing effective decisions support is one of the vital issues for rural communities, specifically when it is related to general medical practices in terms of public healthcare.

The majority of the population in many developing countries live in rural areas having limited access to modern general facilities and to specialized hospitals [4, 22]. For Bangladesh, with a total population of approximately 160 million, there are only approximately 96,000 registered General Practitioners (GP/doctors) available. Although 70% of total population live in rural areas, 75% of total qualified GPs are practicing in urban areas [22]. Although mobile decision support systems (MDSS) technologies have successfully addressed many healthcare issues related to clinical decision support such as for field health workers' information assistance [5], for cardiovascular disease [48], incorporating patient data streams [15], and offering epidemiological support for managing infectious disease [34], few MDSS approaches have focused on decision support for rural communities, or for general practice support, where GPs manage types of illness that present in an undifferentiated way at an early stage of development, or which may require non-urgent intervention and care [1].

To address this gap, we aim to develop and evaluate a MDSS solution approach (called Bhalo-Achi – (it means: *I am Fine*) for providing general healthcare decision support and medical information dissemination. Using design science research (DSR) guidelines [24] we design the solution artifact to address user demand for general practice services. Cognizant of the increasing pervasiveness of mobile phones and social media usage, the solution targets the demand of Bangladeshi rural citizens, who do not have adequate access to healthcare support in general practice.

The proposed approach connects citizens to doctors based on the queries and information provided by the patients. Available doctors evaluate a patient's condition and provide answers for diagnosis or treatment. In the solution, we use a doctor-rating technique [39] which "incentivises" doctors and healthcare professionals to provide expert support and disseminate medical knowledge. We prototyped the solution ensuring direct stakeholder involvement then evaluated the design using the comprehensive evaluation process of Venable et al. [54] in which we employed both descriptive and experimental methods of Hevner et al. [24]. Our findings show the practical usefulness of the decision support: in seeking free medical consultation, finding alternative medicine brands for cost saving, reducing frequency of direct consultation, enhancement of self-management, and reducing doctors' workflow burden. In addition, the user-based rating system, familiar to social media users, encourages the doctors to asynchronously participate in providing free information, ultimately increasing profile awareness.

Utilizing a cloud computing platform (at the service provider's end) for e-health introduces many opportunities for healthcare service delivery, and especially for developing nations. Cloud computing adopts a service oriented architecture (SOA) and supports the functionalities of an integrated e-Health system as a number of inter-operable software services [25]. This fits the client side environment and supports scalability. As well as technical requirements, the social context in which it is embedded must be closely considered in design: in this case remote or rural areas, with relatively poor or less educated citizens, but with good mobile device access and social media literacy. This paper therefore describes an "ensemble approach" [44] to designing the m-health solution in which cloud-computing ensures service integrity at the back end and the mobile application interface ensures effective accessibility at the front end for users with continuing satisfaction and enrichment anticipated with the application in dynamic use.

The paper is organised as follows. The next section describes the problem context and literature background of the study. The following section presents the methodological details followed by the description of the proposed MDSS solution. The section after that provides the system evaluation process. The discussion section provides overall discussion on the contribution of the study while the final section summarises the study presenting its delimitations and further directions for research.

## 2. Background context and literature

### 2.1 Problem context

Proper diagnosis and preventative measures are crucial healthcare strategies, yet people in rural and remote areas may receive poor or inadequate treatment due to the lack of effective medical diagnostic facilities and expertise. They may not even get appropriate consultation, precaution, awareness and education on food, nutrition and lifestyle that could assist them to prevent and manage health complications. Effective decision support and expert advice through professional guidelines would make a huge difference towards tackling their regular non-emergency health condition. Effective consultation establishes a relationship over time, and through effective communication between GPs and patients, can inform specific decision-making processes determined by the prevalence and incidence of illness in the community [1].

According to WHO however, approximately 44% of member states (countries) have less than 1 physician for every 1000 of population. In Bangladesh, there is only one GP for every 1700 patients, against a Millennium Development Goal of at least 2.5 physicians, nurses, and midwives per 1,000 people needed to provide adequate coverage with primary care interventions [55]. For general practice, most of the concerns are related to primary care and service at the first point of medical contact. This service is mainly for providing medical information support for dealing with health issues regardless of the age, sex, and any other characteristics of the individual concerned.

**2.2 Existing MDSS**

Mobile phones using GPRS and Internet technologies provide a useful application platform for data processing, transferring and disseminating for patients and clinicians on an “anywhere, anytime” basis [13, 53]. A clinical decision support systems (CDSS) is a type of specialised DSS application that directly aids in “clinical decision making in which characteristics of individuals are matched to a computerized knowledge base for the purpose of generating patient-specific recommendations [26]. Combining these, mobile Decision Support Systems (MDSS) applications can be classified into three groups: 1) mobile based CDSS for physicians and healthcare professionals (e.g. [3, 28, 38]); 2) MDSS for outreach health workers (e.g. [31, 48]); 3) and MDSS for public use (e.g. [15, 49]).

For example, Krause et al. [30] designed a mobile application for providing physicians with decision-relevant information on potential organ receivers, aiding assessment of forthcoming organ transplants and maintaining security of documentation. Michalowski et al. [40] developed a mobile CDSS for emergency support of different acute pain presentations, while other studies in mobile based CDSS for medical emergency management have identified solution design requirements for emergency triage decision support [47]. Such system solutions primarily support healthcare professionals or clinicians in their own practices rather than enhancing patients’ self-management or monitoring of their medical conditions.

For outreach health professionals, mobile DSS (MDSS) solutions have also been designed, e.g. to enable consistent and quality primary healthcare delivery to rural populations [5]. A tablet-based CDSS for cardiovascular disease management was also designed by Praveen et al. [48] for use by non-physician health care workers (NPHWs) and physicians in a rural Indian context. This involved a four-step process: patient registration, past medical history and medications, risk factor measurements, and treatment advice, all maintained by users, using the open Medical Record System (OpenMRS) to upload locally collected data to a server.

We found however, only a few MDSS focused towards public use or citizen empowerment, providing information guiding diagnosis and self-management. These are summarised in table 1.

**Table 1:** Studies of MDSS for public healthcare information support

| ***Studies*** | ***Design method*** | ***Key technologies*** | ***User groups*** |
|---|---|---|---|
| Bakken et al. [6] | Randomized controlled trials | CPG-related diagnoses | Management of obesity and overweight, tobacco use, and depression in adults and children |
| Amailef and Lu [2] | | components of information extraction and aggregation process, and a CBR-Ontology approach for the MERS system | new opportunity to interact between government, citizens, responders, and other nongovernment agencies in disaster situations |
| Logan et al. [35] | focus-group meetings and pilot-testing of a mobile phone–based remote patient monitoring | Rules based DSS | Management of Hypertension in Diabetic Patients |
| Ramesh et al. 2012 | Prototyping method | Scheduling and signal processing algorithms | Detect type of disease in absence of doctor |

None of the aforementioned studies, however, focuses on designing MDSS solutions for improving the general practices in developing nations. These studies do not provide appropriate end-user technology (e.g. open media or social media based) nor generally design based on real users' demand using replicable IS development methods that contribute principled specifications of design knowledge. Hevner et al. [24] described how DSR, as a powerful IS methodology, is particularly relevant for modern-day IS research, because it helps solution designers confront two of the major long-term issues within IS design: (1) the absence of rigour in designing innovative artefacts and (2) the nature of IS research outputs, many of which produce irrelevant knowledge that is not practically applicable to real-world problem solutions [9,44]. Following the design science approach to instantiate an artefact embedded in its dynamic context thus implies an advance in MDSS research.

Although none of the prior studies directly meets GPs needs for rural citizen's decision support in Bangladesh, the Digital Bangladesh Initiatives towards *Vision 2021* [18], continues to improve resource infrastructure which will support m-health. Bangladesh has high mobile penetration with demand for social media also growing, (GSMA Intelligence, 2014)[1], and despite occasional shutdowns on security grounds, can be expected to grow in parallel with advanced national network infrastructure. The digital mediation of consultancy provides detailed information at the individual level which is useful in developing both a knowledge base and information resources for trainee GPs, and supporting finer-grained information analytics around epidemiological or prevalence data. The purpose of this study is therefore to outline a solution method for supporting general medical information, which can provide two-way information dissemination and insight into patients' details both for their better treatment at the primary stage of healthcare and for informing medical support more generally.

At the same time, healthcare is beginning to embrace social media, which by its nature is egalitarian and available to all with internet access. As a platform for dissemination and interaction, information sharing among practitioners and patients is accelerated and amplified, but also contains the potential for misleading information to be promulgated. Outcomes improve when patients are engaged in their own healthcare and when physicians are active on social media they reach more patients, more quickly and can reinforce important messages more frequently for self-management of treatments or raising awareness around lifestyle choices [8][2]. As information from other sufferers is often shared socially on blogs or forums too it becomes important to manage this aspect.

As mentioned earlier, we operationalised a doctor rating system in our solution artefact, an idea supported at a high level by a UK health minister [39]. Nowadays, patients are increasingly looking online for physician rating, just as they also look for ratings for other products and services. Studies show that patients make decisions based on other people's opinions and even decide to make specific personal appointments: indeed, a growing percentage of new patients visits doctors after they have found information about them online [16]. Rating systems can play an important role in patients' involvement and choices, and help patients to seek health information from sources considered most important or relevant [17]. Studies (such as [32]) found that online doctor rating by patients was a novel way to provide feedback and find information about doctors' performance. Patients' feedback in form of rating systems representing patients' health care experience [45], can have implications for particular providers or resource allocations. Such rating systems can be helpful to the doctors to improve the services they provide.

[1] GSMA Intelligence Aug 2014 *Country overview: Bangladesh* https://www.gsmaintelligence.com/research/?file=140820-bangladesh.pdf&download

[2] http://www.forbes.com/sites/joannabelbey/2016/01/31/is-social-media-the-future-of-healthcare/#7b44daaf48d6

## 3. Research Methodology

The influential paper by Orlikowksi and Iacono [44], which restored to IS a focus on the IT artifact, suggested five meta-categories covering its various conceptions within IS (namely: tool view, proxy view, ensemble view, computational view and nominal view). Of these the "ensemble view" concerns "the dynamic interactions between people and technology" [44, p.126], which includes technologies enmeshed or embedded in their wider systems of use. This category, however, constituted the smallest number of IS articles in their analysis of ISR (information system research) articles over 10 years, despite a strong socio-technical tradition and Orlikowski and Iacono's own observation (p.131) that all IT artifacts are inevitably embedded in a physical setting and (dynamic) discourse of ongoing use. They conclude that detailed practices of the use of IT artifacts must be integrated into theory. We adopted the ensemble view for our solution artifact design in that user involvement was ensured for design and evaluation.

In DSR specific research methods for conducting design and development studies have been introduced although their forms vary due to the focus on designing artifacts [21, 23]. Peffers et al. [46] described a six activity-based methodology: (1) identify problem; (2) define solution objectives; (3) design and development; (4) demonstration; (5) evaluation; and (6) communication. Gregor and Hevner [21] suggested that Peffers et al. [46] offered a well-defined DSR research process that gives a useful synthesized general model from problem identification to solution design and evaluation, - building on other approaches such as Hevner et al. [24]. Hevner et al. [24] proposed seven design guidelines that provide a comprehensive framework useful for shaping the design activities involved in accomplishing the artifact design.

Our research methodology is structured based on the framework proposed by Hevner et al. [24]. In the adopted approach, we grouped the seven guidelines into three broad project phases (described in table 2): *identifying target problems and artifact types*; *artifact creation and evaluation* and finally *research contribution and communication of the result*. March and Smith [36] argued that design research can produce four types of artifacts: specifically, constructs, models, methods, and implementations (instantiations). A construct as artifact is produced when there is a research need for developing a basic language of concepts. A model is a construction of conceptual elements and generally describes artifacts, tasks and situations. A method as a design research artifact results when there is a need for descriptions or specifications of methods or ways of performing goal-directed activities in order to solve or address problems. Finally, an instantiation as artifact is produced when there is a development and deployment of a specific solution product (which may take the form of an actual physical implementation of a design artifact).

In our study, we design an instantiation as artifact, consisting principally of combined technologies, (e.g. cloud computing at the back end and mobile API in the front end) intended to address the decision-making requirements of rural patients for their general medical requirements. Hevner et al's. [24] seven guidelines (Table 2) provide useful (though not entirely prescriptive) criteria for defining a DSR study problem space, specifying a design-based solution artifact, implementing the design solution, evaluating the design artifact and communicating study details and results. In addition, our description here is practically guided by Gregor and Hevner [21], explicating the level of artifact abstraction and knowledge contribution within their recommended schema model for publication.

**Table 2:** DSR phases and guidelines [24, p. 83]

| ***Guidelines of Design Research*** | ***Our artifact design*** |
|---|---|
| *Identifying problems and artifact types* | **Guideline 1:** Design as an Artifact<br>The study has produced a MDSS artefact designed to support healthcare decisions for rural patients in the domain of medical general practices.<br>**Guideline 2:** Problem Relevance<br>The target population is seriously underserved by Millennium goal standards and extant MDSS solutions are not appropriate. General practice healthcare provision is a specific problem of global relevance. This is the essence of the research gap addressed by the DSR study. |
| *Artifact creation and evaluation* | **Guideline 3:** Design Evaluation<br>To demonstrate artifact utility, both focus group and field studies have been conducted with representative stakeholders to capture opinion on the prototype's use.<br>Evolutionary prototyping development in consultation with representative doctors ensured ongoing evaluation and relevance, following established design science guidelines.<br><br>**Guideline 5:** Research Rigor<br>The social media based provisions based on doctor rating technique are used to design the artefact and evaluated using fundamental and generally accepted research procedures (observational and descriptive method).<br>**Guideline 6:** Design as a Search Process<br>Valid healthcare knowledge employed to outline the design artifact in this study. The design process was iterative in order to cope with much of the uncertainty inherent in the problem space (e.g. patients concerns relevant to general practices and emergencies of consequences are separated from the |

| | |
|---|---|
| | primary medical and healthcare requirements) and to allow progressive and incremental solution development at a level so it can be presented to evaluate among the key qualities of the solution. |
| *Research contributions of the artifact and communication of results* | **Guideline 4:** Research Contributions<br>The experimental and focus group outcomes and analysis have shown clear benefits to the target populations in rural area of Bangladesh.<br>**Guideline 7:** Communication of Research<br>This study presents detail relevant to academic, management and industry professionals, and has been verbally presented to such in workshops and presentations during its development and evaluation through focus groups. The application is freely available in Apple's mobile store. |

The evolutionary prototyping method (adapted from [5]) in which a very similar solution is designed for field health workers) was used to identify problems and outline the solution artifact. The prototype development comprised three steps. In the first step we elicited knowledge and understanding of the GP work processes in healthcare delivery. Doctors were asked about requirements and processes of their consultation strategies and medicine prescription. They are also asked about the type of data and information they need to analyse for effective diagnosis and consultation. We found that GPs prefer rule-based reasoning for decision-making. In step two, the initial design from step 1 was refined and separate processes for doctors and patients were developed to ensure the flow of information/patient records. One of the key functions in this step is registration of patient records as well as doctor and healthcare worker profiles on a social media site – namely Facebook. In step three, the system is checked specially for the completion of the prescription and consultation process. After iterative development, the prototype system had evolved sufficiently to be initially evaluated and validated against its targeted practical context of use. In the next section we describe this artefact design.

After the three phases, we invited two professional pharmacists, and two general practioner physicians (GPs) to walk through the system prototype. During the time of meeting they went through the main objectives of the developed app and its operational process in various hand held devices. After that we made some dummy questions in the system for example: *"I am Mr. Rahman, 30 years old. I feel pain in my gum for a few days. I took medicine of paracetamol group but it does not work properly. Now what should I do?* Afterward, we verified if the question was stored in the specific category of the system called 'Dentist' or not as it was selected during the submission of question? We noted the questions was successfully stored in the 'Dentist' category. Then we were waiting for the response against the newly submitted question, and after few minutes the response (answer) came from a registered GP. Then we repeated this test for other categories through which we verified that all the data i.e. questions and responses were respectively being stored under the correct categories. The data of patient's gender and age were also stored in particular locations of the mobile user interface (UI). This pre-evaluation process continued until the system successfully handled 24 enquires and counted response minutes. It was found that the questions from the users were always stored within the specified location of the cloud database. Besides, the doctor search, similar medicine search, rating and commenting functions also worked properly after a few corrections in the coding. This indicated that the prototype was ready for its evaluation.

## 4. Solution artifact

### 4.1 Functional structure of the MDSS Artifact

The developed MDSS artifact comprises four distinct components: a database, governed by a central database server; a stationary front-end for data entry and database administration; a mobile front-end for data distribution; and a synchronization mechanism. These components had to be implemented in relation to identified rural citizen and standard mobile app design requirements: a high security standard, system stability and efficient usability. The mobile computing platform is frequently used in various clinical scenarios [38], so we chose the GUI design using an API suitable for the mobile and other hand held devices. Each front-end was optimized to provide generic and clear representation of the forms for user information entry and display.

Primarily our system provides a healthcare information dissemination platform where GPs, medical students, pharmacists, allied health professionals and laypeople can share health information and contribute to the healthcare process. The comprehensive perspective of the MDSS does not consider only the technical aspects, but also the contexts of the users, the GPs and their locations to enhance its usability and functionality. There are two types of users: 1) users/rural citizens and 2) GPs and health professionals: both can seek medical information by asking questions, find medicine brand lists and local doctors' addresses, however, only type 2 users (doctors and health professionals) can reply to the questions to provide authentic medical information for the general practice.

A major feature of our system is using a doctor rating system to encourage the GPs and healthcare professionals asynchronously to provide support using their expertise and to disseminate medical knowledge. The doctor rating features present options for users to make their own judgement on a rating scale and provide feedback about doctors' performance. The more *likes* a GP receives, the higher rating the GP earns (for instance, in our prototype, one like equals to one point, however, the ratio can be modified), which ultimately increases their profile awareness and future contacts with people as they gain popularity. Figure 1 illustrates the interactions between users through both the user- and back end modules of the system. The user's process initiates through registering with the app and then asking questions or finding medicine brands or local doctors' addresses.

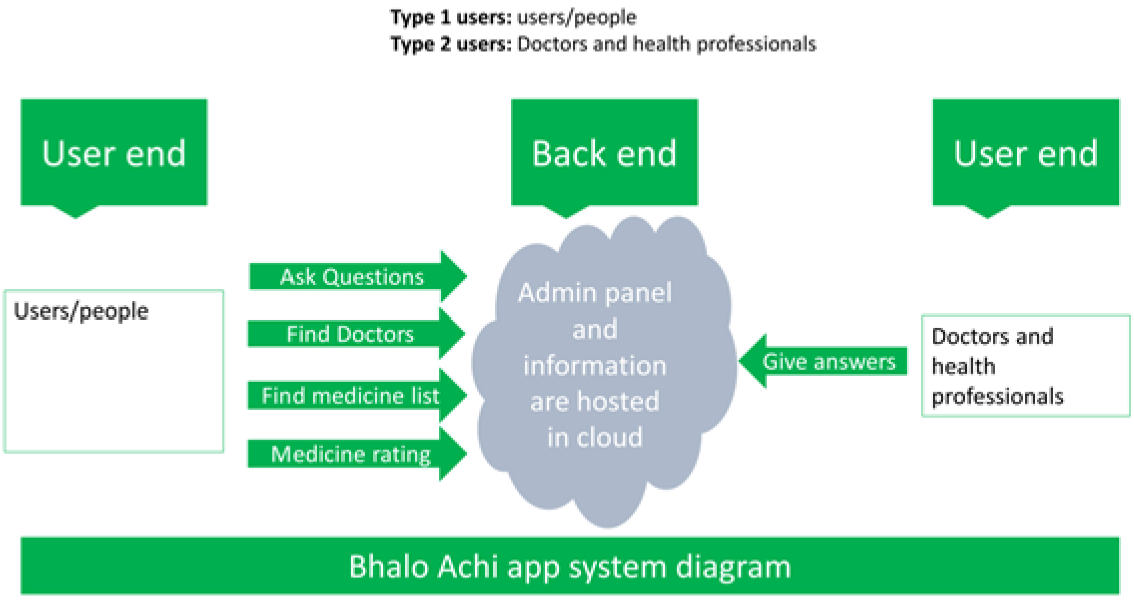


Figure 1: Working components of the m-Health based support system architecture

Through registering into the MDSS system, both the type 1 and type 2 users are linked up with each other. An Internet connection to their mobile phone is required to get access to healthcare support. The Back-End service is managed through a service provider (IT support and control) that also includes checking question and answer quality measures. The architecture relieves the burden on intermediary assistance while users seek information on initial queries and second opinions. In case further consultation is needed, the users can enter into multiple chat sessions, video call (using third party software), or visit the doctor physically using the address from the doctor's profile.

Figure 2 shows the screenshots of how a user can ask and receive decision support in terms of answers from a GP, and  *(like)* the GP if the user finds the answer useful, which ultimately increase the rating of that GP. Figure 3 shows the screenshots of where to search for medicine brand list and GPs profile and address. As the price of different brands of the exact same medicine can vary widely, our proposed MDSS provides lists of different brands so people can compare prices. The brand list also shows ratings (see figure 4) based on a medicine's perceived usefulness and side effects. Our system also allows people to rate and comment on any medicine brand they use to share their experience (see figure 4). Cost and effectiveness information is directly useful to the target users. The medicine rating is done by both the GPs and the users to avoid bias.

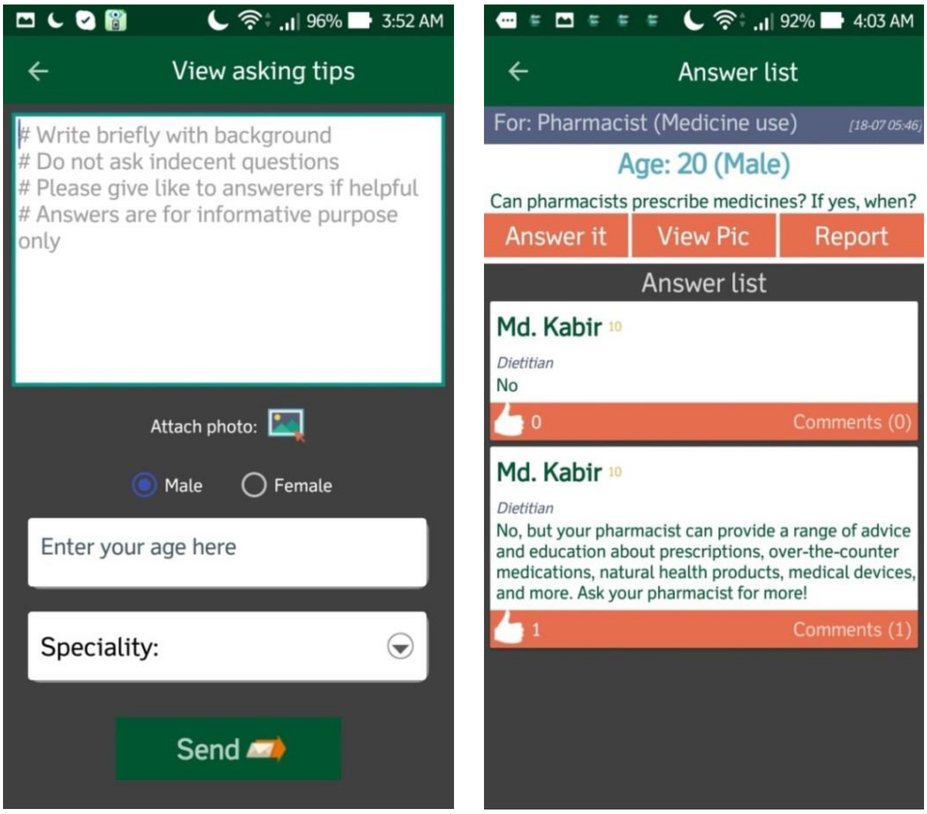


Figure 2: screenshots showing how a user can ask questions and receive answers

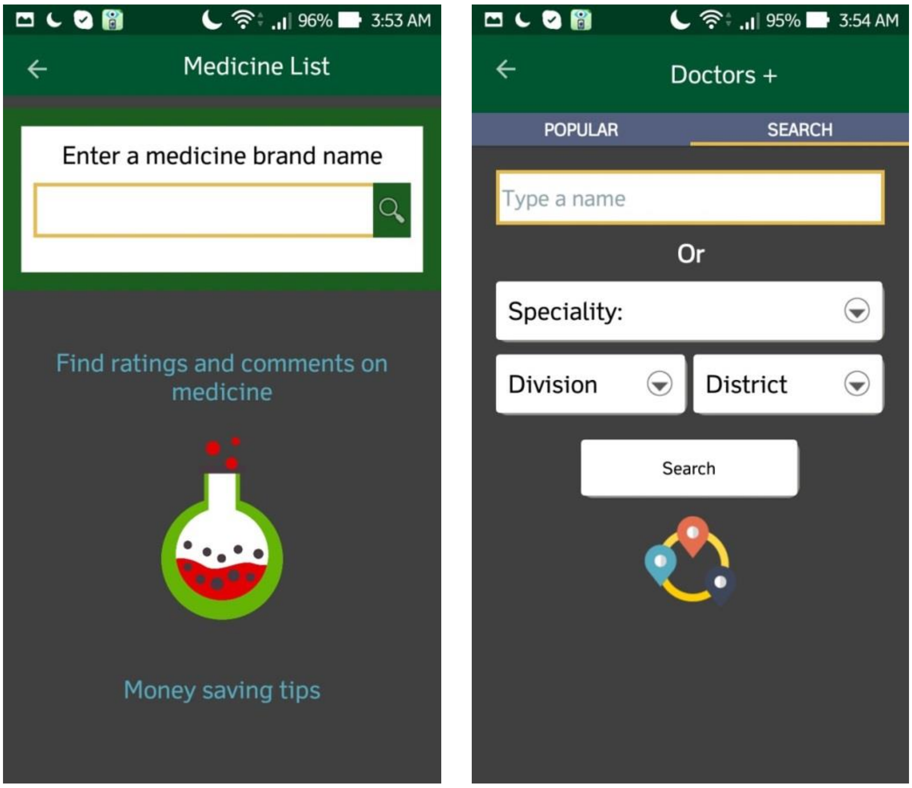


Figure 3: Screenshots of where to search for medicine brand list and GPs profile and address

All the questions from the users and their history, the answers from the GPs, their profiles and rating records, and the medicine lists and their associated rating records are stored on a cloud platform to maintain scalability. A private cloud computing infrastructure was employed for secure data storage. The GPs are required to be registered with their expertise, location and contact details. As the load balancing in bandwidth can be readily handled in the cloud, seamless access to information is easily possible across different geographical locations. The admin panel at the Back End controls the user login and registration processes for every user. The admin function also adds new medicine brand names routinely. The medicine usefulness is rated by the users between 1 to 3 points based on their perceived marginal, or considerable, or high usefulness respectively. Similarly, the medicine side effect is rated by the users between 1 to 3 points based on their negligible, or noticeable, or significant side effects respectively (see: figure 4). This begins to systematise user perceptions of medications more reliably than decontextualized blog or forum posts.

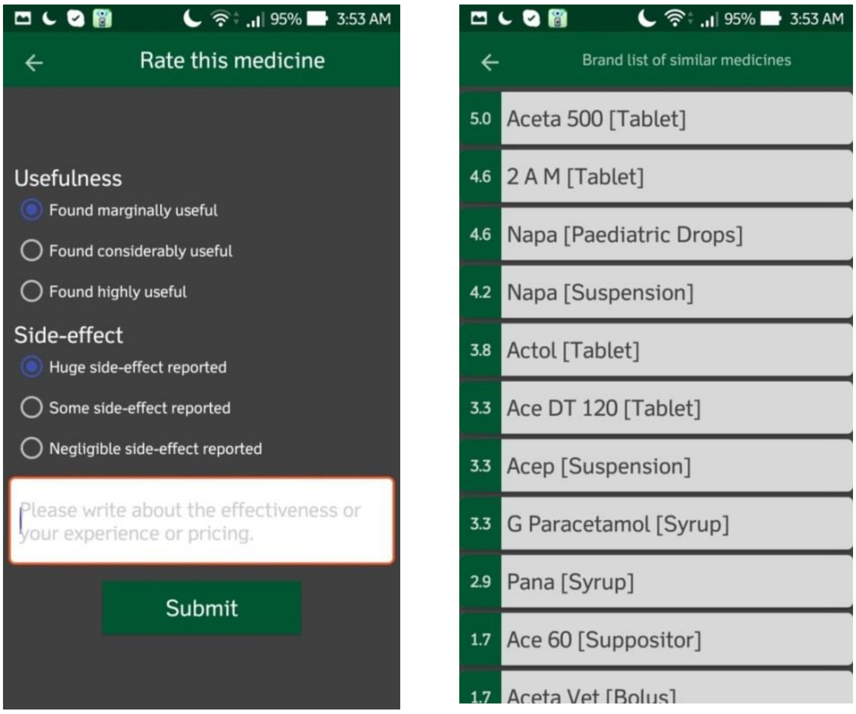


Figure 4: Screenshots of medicine rating form and alternative medicine list, ranked based on user ratings

In summary, the following aspects are central regarding the use of the MDSS.

- Asking questions about health, medicines or disease.
- Giving rating to medicines
- Asking pharmacists to help in choosing an alternative brand to save money, or to learn about medicines.
- Finding nearby doctors and finding their speciality and profile
- Providing a platform to contribute voluntarily to national healthcare and enhance reputation.

- Inviting other health professionals, medical students and laypeople to provide free healthcare support to the general people, especially to rural populations.

### 4.2 Design components

In designing the artifact we adopt the theoretical view of design anatomy presented by Gregor and Jones [20] that defined eight structural components in the solution artifact design. The components are (a) purpose and scope, (b) constructs, (c) principles of form and function, (d) artifact mutability, (e) testable propositions, (f) justificatory knowledge, (g) principles of implementation, and (h) an expository instantiation. These structural components also represent design science considerations for artifact design and implementation of a socio-technical system [21]. This study thus followed established guidelines of IT artifact design to develop the functionalities of the proposed artifact, detailed in table 3.

**Table 3**: Structural components of the artifact design research

| *The specification of the design theory* | *Presented in this research* |
|---|---|
| The purpose and scope of the artifact are addressed | Designing a MDSS application for providing online healthcare support information for rural patients' decision support. Sections 1 and 2 describe the purpose and scope of the study. |
| Principles of form and function incorporating underlying constructs are described | For designing the solution artifact, rule based algorithms were used to control the logic of information presentation. The functional processes of the proposed solution are detailed in Section 4. To meet data integrity and other diversity requirements, we used the well-established prototyping development method. The functionality of the design is thus founded on justified constructs and model of data flow established in system development. |
| Artifact mutability is addressed | The new design artifact has been formulated to meet the need of rural citizens within the context of support for general practice. The proposed solution model is applicable for other information dissemination purposes. By replacing users and medical information details, we can readjust the model without any major technical modification in place. As the system is used it should converge on reliable ratings and increasingly relevant information |
| Testable proposition of the design artifact is defined | Evaluation of the IT artifact with focus groups and field studies have been undertaken by experiments and direct user involvement (see section 5). |

| | |
|---|---|
| Justificatory knowledge (kernel theory) is provided | The proposed solution as an IT artifact is based on user real requirements captured through prototyping phases that are well defined and referenced. The iterative development and evaluation process are also well established in IS and are related to real and known issues within the context of information requirement (see section 4). Medical knowledge is verified by physicians and pharmacists. |
| Principles of implementation are presented | We described the working principles of the proposed system for providing decision support for the need of rural patients. Technical details are provided in section 4. |
| An expository instantiation is given | The functional details with various forms are defined and illustrated in this paper. The software is freely available on the Apple store. The exposition and the generic value of the artifact is further validated by its presentation both to academic and industry audiences. |

## 5. Artifact evaluation

As a crucial component of the research process a comprehensive evaluation process must be employed. Hevner et al. [24] state that "evaluation of a designed IT artifact requires the definition of appropriate metrics and possibly the gathering and analysis of appropriate data. IT artifacts can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes" (p. 85). In design science research, particularly for software use by end users, a solution artifact must be evaluated to demonstrate its value for the target user group with evidence addressing a set of relevant criteria such as validity of the artifact, efficacy, benefits, and efficiency of the artifact [21]. Many studies have proposed methods for rigorous evaluation of design artifacts. Hevner et al. [24] offered five general approaches- observational, analytical, experimental, testing, descriptive approaches. Hevner's team also suggested various techniques such as (for observation) using case and field studies; for the analytical method, static analysis, architecture analysis and optimization; and for the descriptive method, informed argument and the use of scenarios to construct convincing arguments for the artifact's utility, usability or validity [21]. In our study, we employed descriptive and observational methods to evaluate the qualities of the proposed artefact using Venable et al.'s [54] framework for conducting the entire evaluation activities in our study. The following table illustrates details of the steps.

**Table 4:** Overall summary of evaluation activities

| *Processes (Venable et al. 2016)* | *Descriptions* |
|---|---|

| | |
|---|---|
| (1) explicate the goals of the evaluation, | Utility, efficacy and reliability |
| (2) choose the evaluation strategy or strategies | Descriptive and observational approaches |
| (3) determine the properties to evaluate | Usability, efficacy, reliability |
| (4) design the individual evaluation episode(s) | With service providers and service receivers |

Under the descriptive method, a focus group was used during the artifact design for capturing detailed scenarios around the solution artifact to demonstrate the utility. As a part of observation method, value was demonstrated by conducting a field study monitoring the artefact-in-use in targeted practical and every-day living environments. These are detailed next.

**5.1 Focus group evaluation**

Tremblay et al. [52] proposed an approach of using focus group both for exploratory and confirmatory purposes of artifact evaluation. We adopted the approach for confirmatory purposes due to our project's requirements. Following the guidance proposed by Nieveen and Folmer [42] we conducted a focus group to collect expert opinion for further revision and value assessments. Both types of representative user were included.

**Table 5:** Evaluation outcome of usability from confirmatory focus group

| ***Addressing criteria*** | ***Outcome (Yes/No)*** | | | | | ***Practitioner's (P) comments (Doctor/User)*** |
|---|---|---|---|---|---|---|
| | ***Doctor*** | | | ***Patients*** | | |
| Useful information can be produced from the system for my decision making | **Y** | **Y** | **Y** | **Y** | **Y** | D1: 'the system is very useful to make primary decision but difficult to give critical suggestion without visit'<br>D2: 'doctor can take decision for his patients reviewing the details question of patients<br>D3: 'primarily doctor can provide decision and help to overcome patient's frustration at preliminary level' |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | U2: ' we get many suggestion from different doctors and compare major response which is helpful for us'<br>U1: 'system is useful and help for follow-up program' |
| System is helpful for time saving | **Y** | **Y** | **Y** | **Y** | **Y** | D1: 'excellent package for rural people due to bad communication system'<br>D2: 'rural people can take service from specialist within short time which is also cost effective'<br>D3: 'people can cut-off time like traffic jam using this system,<br>U2: 'doctor's busyness can be overcome by text which is relax and time effective'<br>U1: 'can get fast feedback rather than physical visit' |
| Easy to find information from the system | N/A | **Y** | **Y** | **Y** | **Y** | U1: 'easy to use and well defined content'<br>U2: 'I found it is useful to search medicine and can compare'<br>D2: 'contents are very easy and helpful'<br>D3: 'I found it is standard apps for comfortable use' |
| Daily living practice has changed using the system | **Y** | **Y** | N/A | **Y** | N/A | D2: ' I always check the system for any notification'<br>D1: 'in every morning at first I find system if any notification left'<br>U1: ' I always depend on this system to seek healthcare information' |

In rural areas workplace accidents, or sudden events such as a stroke can take time to get healthcare from professionals. Response efficiency is thus an important aspect of system effectiveness, e.g to reduce the severity of injuries or expedite urgent treatment. The moderator asked questions about how quickly users received responses using the system. Our prototype got mixed views from various doctors and patients, but most provided constructive suggestions. One user effectively stated *"At the moment subscribers are low in this preliminary phase so we get feedback quickly. But what about the future. With many users, will the service be so fast"?:* a statement also supported by another user. We also asked the same questions to the doctor. One response was – *"please consider the financial factor, this system is voluntary, it is quite difficult to provide service individual to individual, though I have strong willingness to serve*". Another answer was indirect; *"administrator needs numerous therapeutic area's expert to provide quick answer"* whereas another thought "*we need full time general practitioners who can serve primary care to the patients"*.

The use of alternative approaches to provide healthcare can significantly help people living with severe problems. Complementary and alternative healthcare approaches have become more and more widely used in Western societies. The terms *complementary* and *integrative* refer to the use of non-mainstream approaches together with conventional medical approaches. Our next query was to find out – can the system be considered as a complementary alternative to physical visits? One GP gave his opinion – *"possible, but not for all disease, primary solution can be given reviewing the text provided by the user, but in case of critical injury he/she must have to visit a specialist facility to examine the symptom or types of the injury". Another doctor at first answered that "there is no alternative of face to face visit especially for chronic disease, but you can get quick guide line, primary conduct, can get primary treatment suggestion etc."* he also added *"with the help of Skype video call it is possible to understand and measure some disease like skin disease. So in this sense you can consider as an effective alternative way of physical visit".* However patients were satisfied with this question and agreed its suitability for initial primary care. They also get notifications from numerous doctors and can compare and validate advice.

Healthcare social media consulting is a bubble economy at the moment. Social media is a powerful tool for communicating to patients, other physicians and interacting with scientists across the world. But most GPs and healthcare providers have little free time. In order to facilitate easy communication between medical professionals including the ability to ask each other questions, share information, opinions, observations, and more, a number of social networks and apps can be introduced, evaluated and integrated. We were also concerned to question– can this system use social media functionality to improve doctors rating and provide reputational information? One direct answer from an expert was *"Connectivity is productivity. We consider service as a product, anyone can increase his/her position by providing proper service at real time."* Another described *"this idea is new in our country but in many developed countries this system is old. They improve and explore their popularity by social media. This application can help doctors improve their ratings and people can consider according to their rating point. On the other hand users also analyse which doctors are more engaged to give answer and to which doctor people gives more rating. We are not used to this is in our country but it has potential".* A patient response was that he could find the best doctor by reviewing the rating point and he was confident to find authentic advice without any mediator.

Currently many people find primary care information in the pharmacy, medicine shop or from an educated person. We got one patient's opinion: *"if I fall in minor problems, it is difficult to go to a doctor due to time involved or sometimes considering cost. In this situation I go to medicine shop and take suggestion from the seller. I know this may not a proper way but we are used to this system."*

### 5.2 Field study evaluation

To conduct the field study we designed a process for collecting summative primary data for quantitative analysis. Questionnaires were distributed to the end users and collected from participants at the end of the completion of the task and after using the system. A total of 120 questionnaires were collected and after scrutinizing we excluded 20 responses due to error so finally 100 responses were included for final data analysis. All the respondents were moderately skilled in using the system.

The main objective of the field study was to collect data from end users to evaluate the system, process, reliability and satisfaction and decision maker's perceived usefulness and ease of use perceptions. The questionnaire consists of 11 questions, and participants were asked to rate each question with regard to usability, efficacy and reliability of the systems [33] as well as usefulness, and ease of use [12]. All the evaluation questions are contained in table 1 showing each answer scored on a 5-point Likert scale where 1 represents strong disagreement, through 2 (disagree), 3 (neither agree nor disagree), 4 (agree), and 5 (strongly agree). The values of mean and standard deviation response are reported for each question (see Table 6).

In this study, the three key research variables were derived using appropriate tests of internal consistency and reliability with a Cronbach alpha coefficient of 0.6833, 0.6383 and 0.6686 respectively, (table 7) suggesting the items are more or less well measuring the applicable construct. On the other hand all the composite reliability are greater than 70% which is a typical research threshold for accepting Cronbach's alpha as an indication of reliable measurement. Since the sample is relatively small and the Likert scale items are ordinal, these figures must be treated as suggestive only but Nunnally, Bernstein, and Berge [43] have observed that such values are acceptable for preliminary research.

For observed multiple variables with a similar pattern of responses, in addition to Cronbach alpha coefficients, we calculated factor loadings. A higher factor loading suggests a supposed causal effect between a latent variable and an observed indicator, or at least their correlation. A rule of thumb is that acceptable factor loadings should be 0.40 and above [14] taking into consideration convergent and discriminant validity. Here, all the factor loadings of the items were greater than 0.50 (Table 6) except the question on response speed of the system suggesting these items affirm the usability, reliability and efficacy of the system. Correlation is one of the most common and most useful statistics. A correlation is a single number that describes the degree of relationship between two variables. In this study correlation coefficients were computed between these variable constructs to compare elements of the questionnaire. This is shown in table 7.

*5.2.1 Results*

The results of the questionnaire study indicate that participants found that the Bhalo Achi is useful (mean = 4.87, SD =0.464) with 91% of respondents strongly agreeing with this. 92% also strongly agreed that using this system reduced time to seek healthcare advice (mean = 4.84, SD = 0.615) whilst

87% of respondents strongly agreed with both requirements ($\chi^2$ = 103.423, df. =12). 80% neither agreed nor disagreed on ease of find information from the system whereas 86% considered daily living practice would be influenced by the system. 41% shows dilemma on benefits of using system whereas 12% respondents disagree with this response and 24% strongly agreed. 17% people agreed the information from the system are evidence-based and 19% strongly agreed but 52% participants showed dilemma (neither agree nor disagreed) that the personal data are protected. 7% respondent showed that the system is effective but questions arise that the protection of personal data ($\chi^2$ = 81.112, df. =12). Again 79% strongly agreed in both case that they always seek health information from the system and they fell change in their daily living practice ($\chi^2$ = 172.717, df. = 9). However all the Chi-Square tests are significant at 95% confidence level for total participants of n=100. Again the correlation revealed association between always seeking healthcare information and usefulness of system as significant $r = .66$, $p < .000$, two tail. And another strong association was found on benefits of primary healthcare $r = .74$, $p < .000$, two tail. Equally, regularly seeking healthcare information and benefits of primary healthcare also have strong significant relation $r = .81$, $p < .0001$, two tail. However time reduction in seeking medical advice and primary healthcare benefit also shows significant relationship $r = .83$, $p < .0001$, two tail. From these results we may conclude that those who regularly seek healthcare information using this system perceives benefited and find the system is useful, particularly on the basis of time saving.

**Table 6:** Descriptive and Reliability Tests

| ***Items*** | ***Factor Loading*** | ***Mean*** | ***Std. Deviation*** | ***Composite Reliability*** | ***Cronbachs Alpha*** |
|---|---|---|---|---|---|
| **Usability** | | | | | |
| Useful Information for my decision making | 0.7458 | 4.87 | 0.464 | 0.8095 | 0.6833 |
| Helpful for reducing my time for seeking medical advice | 0.8946 | 4.84 | 0.615 | | |
| Easy to find my information | 0.5589 | 3 | 0.512 | | |
| Change in daily living practice | 0.6493 | 2.91 | 0.404 | | |
| **Efficacy** | | | | | |
| I always seek healthcare information | 0.8141 | 4.78 | 0.561 | 0.7798 | 0.6383 |
| Provides benefits of my primary healthcare | 0.9078 | 4.8 | 0.569 | | |
| Provides quick response from healthcare professionals | 0.3929 | 3.5 | 1.078 | | |
| Effective for my health seeking behavior | 0.5696 | 3.35 | 0.903 | | |

| | | | | | |
|---|---|---|---|---|---|
| **Reliability** | | | | | |
| Provides evidence based public health content | 0.8293 | 3.36 | 1.01 | 0.8216 | 0.6686 |
| Suggestions are explained appropriately | 0.6355 | 2.96 | 0.53 | | |
| I think personal data is protected | 0.8582 | 3.39 | 0.886 | | |

**Table 7:** Correlation matrix

Correlation matrix (Pearson) & P- Values

| Variables | USE1 | USE2 | USE3 | USE4 | EFF1 | EFF2 | EFF3 | EFF4 | REL1 | REL2 | REL3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USE1 | **1** | **0.000** | **0.034** | **0.001** | **0.000** | **0.000** | 0.368 | 0.397 | 0.779 | 0.313 | 0.084 |
| USE2 | **0.528** | **1** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | 0.174 | **0.000** | 0.546 | 0.470 | **0.038** |
| USE3 | **0.212** | **0.481** | **1** | 0.335 | **0.001** | **< 0.0001** | 0.470 | 0.082 | 0.563 | **0.003** | **0.014** |
| USE4 | **0.314** | **0.470** | 0.097 | **1** | **< 0.0001** | **< 0.0001** | 0.084 | **0.005** | 0.299 | 0.867 | 0.123 |
| EFF1 | **0.665** | **0.687** | **0.316** | **0.491** | **1** | **< 0.0001** | 0.869 | 0.354 | 0.283 | 0.165 | 0.605 |
| EFF2 | **0.743** | **0.832** | **0.416** | **0.492** | **0.811** | **1** | 0.328 | **0.003** | 0.835 | 0.466 | 0.120 |
| EFF3 | 0.091 | 0.137 | 0.073 | 0.174 | -0.017 | 0.099 | **1** | **< 0.0001** | **< 0.0001** | **0.013** | **< 0.0001** |
| EFF4 | 0.086 | **0.375** | 0.175 | **0.281** | 0.094 | **0.295** | **0.555** | **1** | **< 0.0001** | **0.001** | **< 0.0001** |
| REL1 | -0.028 | 0.061 | 0.059 | 0.105 | -0.108 | 0.021 | **0.538** | **0.480** | **1** | **0.006** | **< 0.0001** |
| REL2 | 0.102 | 0.073 | **0.297** | -0.017 | 0.140 | 0.074 | **0.247** | **0.325** | **0.272** | **1** | **0.003** |
| REL3 | 0.174 | **0.208** | **0.245** | 0.155 | 0.052 | 0.156 | **0.492** | **0.522** | **0.642** | **0.291** | **1** |

*Values in bold are different from 0 with a significance level alpha=0.05*

Lower diagonal indicates correlation and upper diagonal indicates respective p-values

Since launch we have found an increasing number of registrations both for healthcare professionals and users. Figure 5 presents a screenshot taken on 14 December 2016 showing that since the launching of the Bhalo Achi apps on June, 2016, 114 health professionals and 3081 users have registered into our system. At critical mass this may transform intention to use shown in the pilot into regular use. Table 8 shows the users and health professionals' cumulative registrations figures.

**Table 8:** Number of registrations

| ***Month*** | ***Health professionals*** | ***Users*** |
|---|---|---|
| July, 2016. | 23 | 829 |
| October, 2016. | 51 | 2022 |
| December, 2016. | 114 | 3081 |


Figure 5: Screenshot showing total users count

## 6. Discussion and conclusion

The paper described a solution artifact to support the general practice needs of underserved citizens in Bangladesh. The design uses mobile phone access to general practice cloud services forming a social media based community of support in which relevant information is shared between professionals and patients, diagnosis and treatment is expedited, and reputation of doctors and medicine brands provide information for patient decision making, validly and securely. The system provides ubiquitous decision-relevant patient data retrieval, documentation and authentication, leading to a faster and more reliable primary care advice by registered and accountable physicians. This simple, flexible and low-cost approach to healthcare support addresses the issue of digital divide in Bangladesh, but generalises to other nations, developing or otherwise, that have underserved rural or remote communities and an adequate mobile network infrastructure.

As an instantiation developed using design science guidelines (for our instance, the ensemble view assisted us to ensure appropriate technology design for target users while the seven guidelines provided a sequential direction for designing the entire solution artifact), the study has contributed by demonstrating the usability, efficacy and reliability of the approach, and showing how use has grown over six months since launch. Further growth may be organic, through word of mouth, or through more centralised mandates depending on healthcare policy decisions. As a generic solution as the framework can be applied in other areas of healthcare decision support, whether for general lifestyle and well-being information or dedicated to more urgent and specialised interventions.

The main limitations of the study concern the evaluation of efficacy and utility as critical mass is reached, a concern anticipated by respondents. The cloud platform allows scalability but a limitation is that the doctors are available on a voluntary basis, which may not be scalable or sustainable. This can be obviated by funding a dedicated service pool, possibly through supervised University interns or centralised resourcing, as user-pays may not be viable in the shorter term. Similarly, the rating system has not been evaluated in practice, and might require refinement as experience emerges. Sites with user ratings such as tripadvisor.com had to adjust their systems to minimise fraudulent reviews or scores unjustified by narrative reviews. Whilst reputations can be enhanced which may incentivise some doctors, the implementation consequences may require further evaluation. Finally, the users sampled were moderately skilled in use of the system, and perhaps a wider sample of users would indicate unanticipated operational problems with widespread deployment.

Further study can address these limitations, and explore, in conjunction with district health authorities, implementation strategies. Feasibility in other underserved markets such as regional Australia, which has analogous problems of healthcare access, despite relative poverty and worse health [50] would also be relevant to explore further, along with evolutionary refinements to the design as appropriate.

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